



**RDECOM**



***TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.***

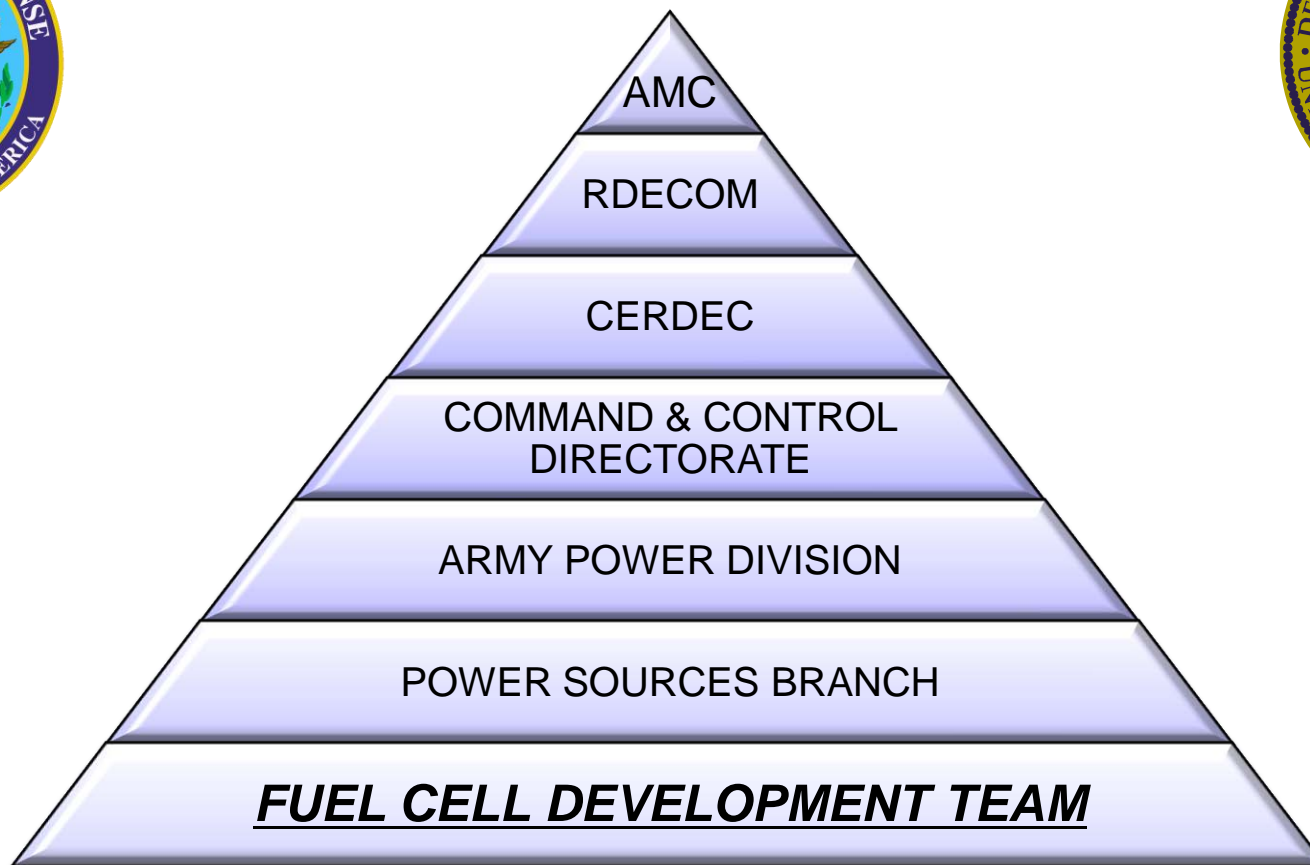
**CERDEC Fuel Cell Team: U.S. Army CERDEC Field Evaluation  
and Testing of Soldier and Man-  
Portable Fuel Cell Power Sources**

**2009 Fuel Cell Seminar & Expo –Palm Springs, CA – 19 Nov 2009**  
**Jonathan Novoa, Shailesh Shah, Marnie de Jong, Mike Dominick, JJ Kowal**

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# Department of The Army: Who We Are



## Army Power Division & CERDEC Fuel Cell Team Missions



### Sensor & Soldier Power

- *Potential Benefits*
- *Recent Test Results*



### Man Portable Power

- *Potential Benefits*
- *Recent Test Results*



### Demonstrations & Exercises

- *Aberdeen Test Center*
- *Joint Readiness Training Center, Ft. Polk*
- *West Point Military Academy*

To conduct research, development, and system engineering leading to the most cost-effective power, energy, and environmental technologies to support Army's soldier, portable, and mobile applications.

**ATOs**

**ATO R.LG.2009.01**  
**Mobile Power**

*Transitional Hybrid Power Source, Log-fueled  
Waste Heat Recovery  
Power Centric Mobility applications*

**ATO D.CER.2008.08**

**Power for Dismounted Soldier**

*Half-Sized BA5590 Li/CFx Battery*

*Half-Sized BA5590 Li-Air Battery*

*Soldier Conformal Rechargeable Battery*

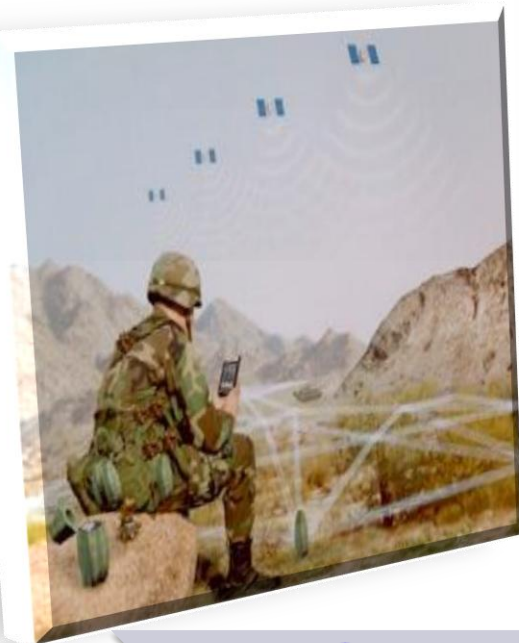
***Soldier Hybrid Methanol Fuel Cell Power Source***

***Soldier Hybrid Fuel Cell Power Source***

***Portable Hybrid Power Sources & Chargers, JP-8 fueled***



To Rapidly Develop & Transition Suitable Fuel Cell Technologies to Applications where they are Most Needed



**Sensors**  
**< 5 W**



**Soldier Power**  
**5 – 100 W**



**Man Portable**  
**100 – 500 W**

# Fuel Cells for Sensor and Soldier Power

## *Current Programs & Recent Lab Testing Results*

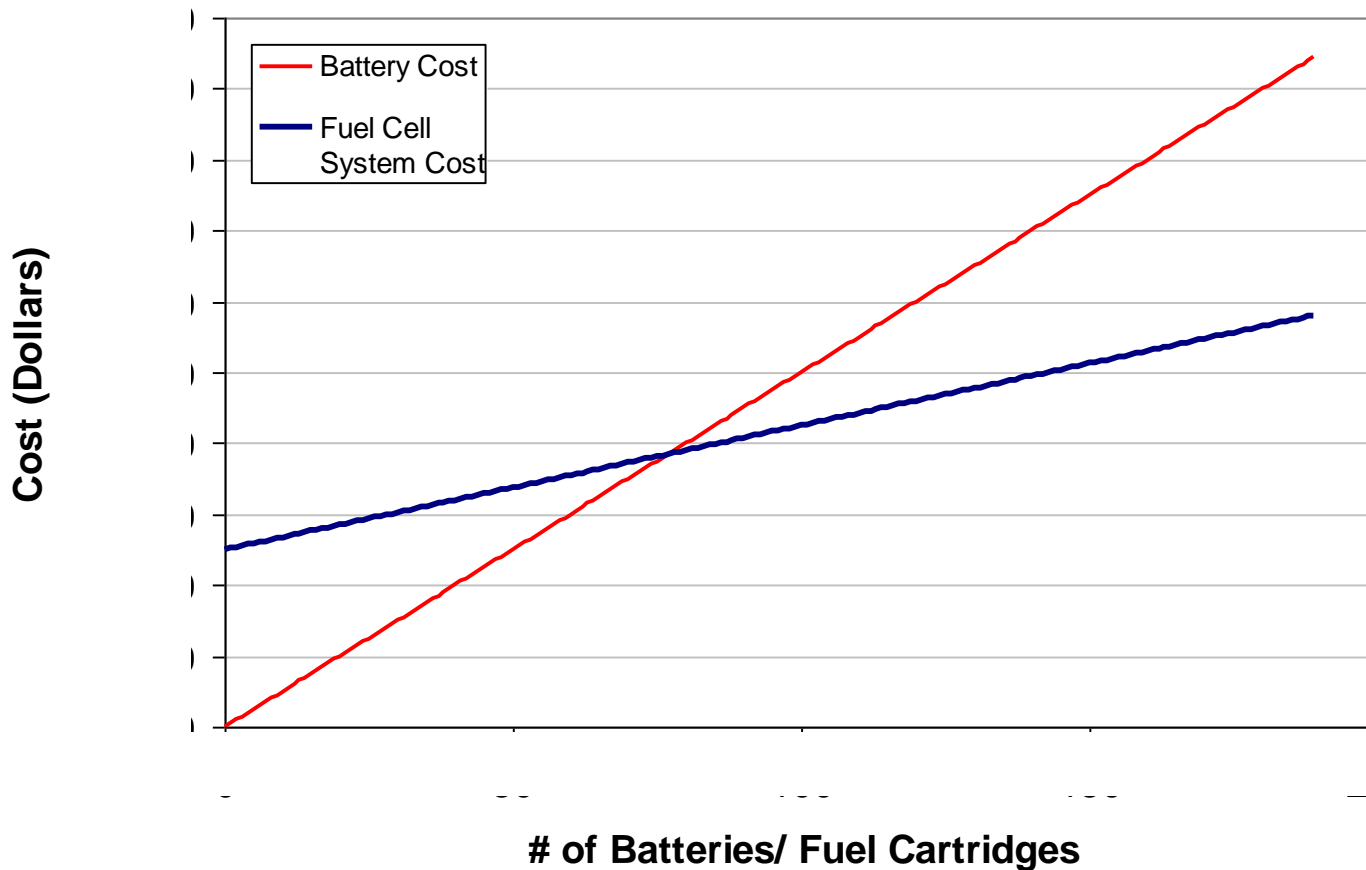




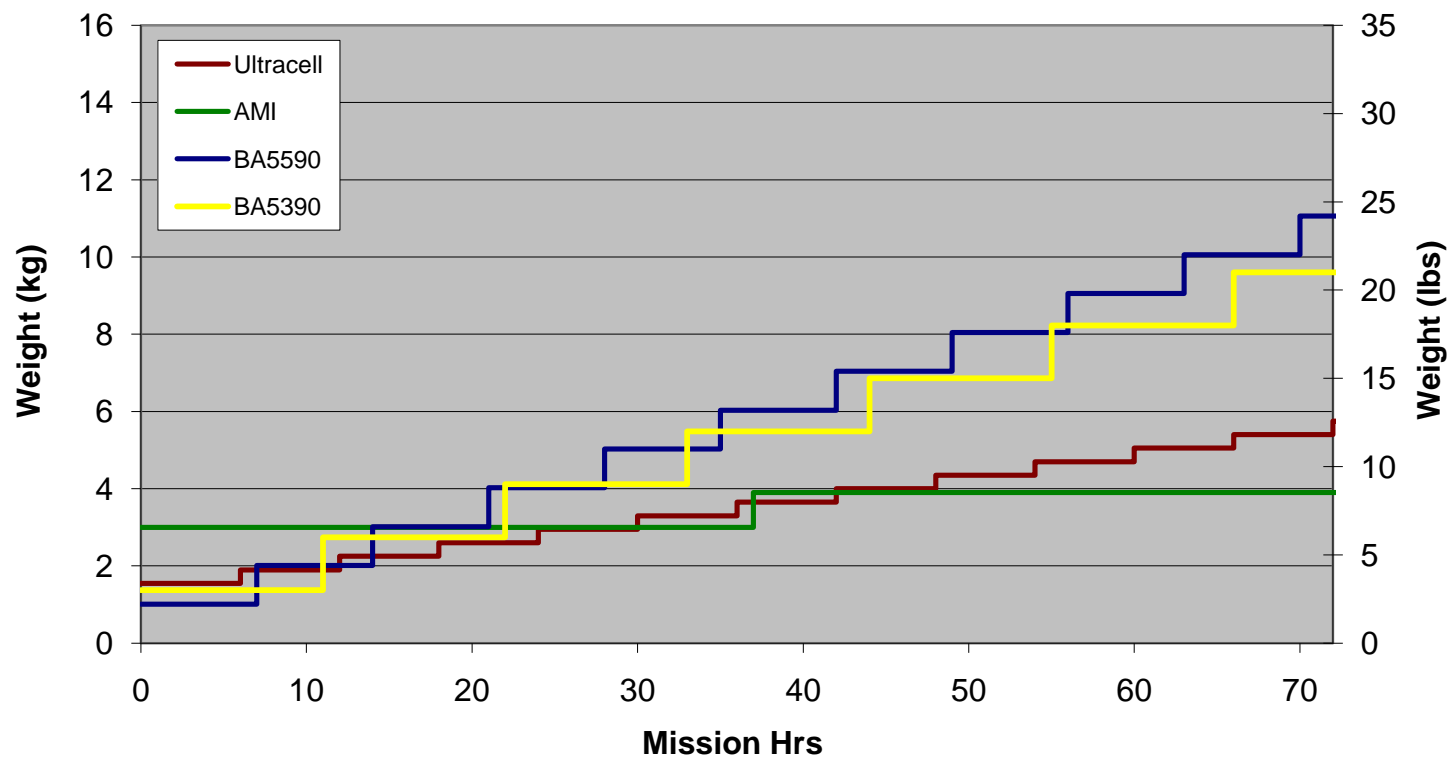
- Longer runtimes than current batteries for comparable form factors
- Logistic advantages related to handling and lifecycle costs
- Cheaper than current batteries for comparable power needs



Cost Comparison for Operating Batteries vs. Fuel Cells



## 25W Starting Mission Weight vs Mission Hours



## Fuel Technology

## Current Efforts

Direct Methanol



Reformed Methanol



Chemical Hydrides



SOFC



Bio - Fuels



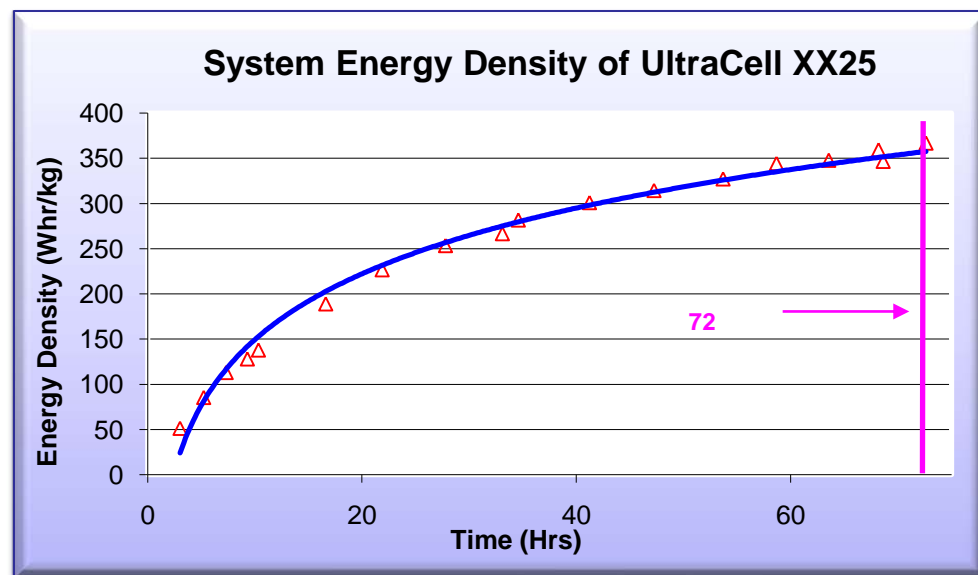
In Development with CERDEC and DARPA

Rated 25W continuous  
Reformed Methanol Fuel Cell (RMFC)  
Fuel: 67% Methanol / 33% Water

Dimensions: 9.3" x 5.3" x 1.8"  
Start Up Time: 20 min.

System Dry Weight: 1.2 kg  
Fuel Cartridge Weight: 0.3 kg

25W Mission Energy Density:  
24-hr 230 Whr/kg  
72-hr 360 Whr/kg



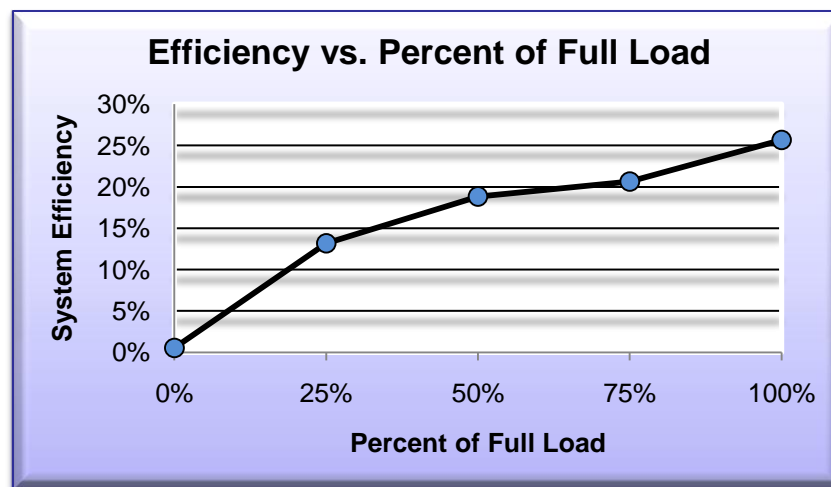
## Progression from XX25

Rated 55W continuous (**110W Peak**)  
 Reformed Methanol Fuel Cell (RMFC)  
 Fuel: 67% Methanol / 33% Water

Dimensions 13" x 8" x 4"  
Start Up Time: 25 min / Hybridized

System Dry Weight: 2.7 kg  
System Efficiency: 26.0 %

55W Mission Energy Density:  
 24 hr 265 Whr/kg\*  
 72-hr 410 Whr/kg\*



\* Calculated based on initial data only

Developed with CERDEC and DARPA

Rated 60W continuous (**100 W Peak**)  
Solid Oxide Fuel Cell (SOFC)  
Fuel: Commercial Propane Canisters

Dimensions: 10.25" x 9" x 4"  
Start Up Time: 15min.

System Dry Weight: 2.8 kg  
System Efficiency: 18.0 %

60W Mission Energy Density:  
24 hr 400 Whr/kg  
72-hr 760 Whr/kg





# Fuel Cells for Man Portable Power

## *Current Programs & Recent Lab Testing Results*



## Auxiliary Power/ Battery Charging

- Bridge power gap between batteries and generators
- Greater efficiencies than TQGs and vehicle power
- Reduced noise and heat signatures
- Enables remote, portable battery charging capability where other power sources are not practical
- Low emissions

## Fuel Technology

## Current Efforts

Direct Methanol →



Reformed Methanol →



Ammonia Borane →



Sodium Borohydride →



SOFC →



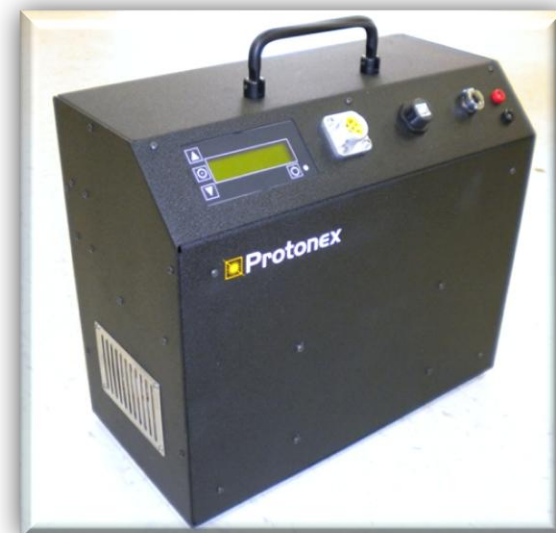
Developed with CERDEC & ARO

Rated 100W continuous  
Solid Oxide Fuel Cell (SOFC)  
Fuel: 100% Pure Propane

Dimensions: 14" x 6.75" x 3.75"  
Start Up Time: 50 minutes

System Dry Weight: 6.9 kg  
Fuel Cartridge Weight: 0.8 kg

Fuel Consumption: 38g/hr  
System Efficiency: 18.6 %



 **Protonex**<sup>TM</sup>  
The Next Generation of Portable Power<sup>TM</sup>

# Recent Exercises & Demonstrations

### Ballistic Testing:

*Determine Fuel Cell and Cartridge Safety*  
*.50 Cal Incendiary Rounds*

### Targets:

*Fuel Cells in Operational Configuration*  
*Propane Canisters*  
*Methanol Cartridges*

### Results:

*Benign Release of Fuel from Containers*  
*No Incident on Fuel Cell Systems*





## Purpose:

*Utilize the UltraCell XX25 RMFC as a Remote Power Source for Dismounted Soldier Applications*

## Feedback:

*Users enjoy Hotswappable Capabilities  
“...Good Mission Extender”*

### Environmental Conditions

Temp: 70-100°F

Humidity: 60-100%



Toughbooks

Radios

Charging



### Purpose:

*Conduct a Human Factors Analysis on the UltraCell XX25 RMFC*

### Test Factors:

*Ergonomics*

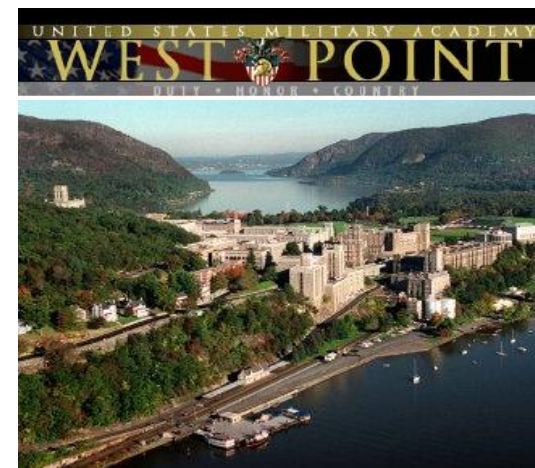
*Ease of use*

*Ability to Read Display (Fuel, Error Codes, etc.)*

### Testing Results:

**Phase 1: August – December 2009 (Classroom)**

**Phase 2: Summer 2010 (Field Demo)**



- Fuel Cells have shown great potential for meeting the increased energy needs of the dismounted soldier
- Many current systems have increased reliability and ruggedness moving from TRL 5/6 to 6/7
- No one technology has shown it will be the sole solution for the military – both fuel and fuel cell need to be safe and user acceptable
- Test and evaluation of fuel cell power systems plays a vital role in assessing the state of technology and transitioning to the procurement stage





## Questions?

